Cover Page

Project Title: Solar Powered Container Farming: A Model for Sustainable Food Production

Project Team:

Name	Title	Organization	Email	Phone
*Eric Buchanan	Director, Renewable Energy Program	WCROC	buch0123@ morris.umn.edu	320-589-1711
Joel Tallaksen	Renewable Energy Scientist	WCROC	tall0007@umn.edu	320-589-1711
Kent Peterson	Owner	Bees and Greens, Benson MN	petersonrestoration @gmail.com	320-321-4848
Ed Brands	Associate Professor, Environmental Studies	UMN Morris	ebrands@ morris.umn.edu	320-589-6209
Uwe Kortshagen	Professor, Mechanical Engineering	UMN	korts001@umn.edu	612-625-4028
Nate Eylands	Professor, Horticulture Science	UMN	neylands@umn.edu	612-624-4742
Vivian Ferry	Associate Professor, Chem Eng & Material Science	UMN	veferry@umn.edu	612-625-7522
Syd Bauer/ Vern Simula	Members	West Central MN Climate Network	syd.r.bauer@ gmail.com vern.simula@ gmail.com /	651-395-0832 218-591-5722

*Project Lead/PI

Impact Goal:

Growing food and getting it to local communities is dependent on weather conditions and consumes energy -- especially in northern climes. Producing that energy with fossil fuels is changing the climate, imperiling the ability to economically produce food which leads to food insecurity in local communities. Our project will demonstrate a model for growing high value crops in Minnesota year-round that lowers the carbon footprint, increases food system sustainability, and removes barriers from farmers under-privileged in land and capital. A food system powered by clean energy and capable of growing high value crops independent of weather could be transformative.

Problem Statement:

Minnesota relies on food production from distant states and countries increasing the carbon footprint of our food supply - especially in winter. Moreover, climate change induced changes to weather patterns here in Minnesota and in other areas we rely on for food are increasing the risk to our food security. Containerized farming allows food production without the need for long-distance, fossil-fuel based transportation, and is weather independent while using less land and water. However, small-scale commercial ventures in containerized farming often struggle due to high energy costs for lighting and indoor climate control.

Deep winter greenhouses exist in MN but generally have high heating costs and can only produce cold hardy vegetables like lettuce which can also tolerate low light levels. Unfortunately, crops that are suitable for winter greenhouses do not have high market value. Consequently, high value vegetable crops sold in MN grocery stores during the winter must be shipped thousands of miles from growing areas in California, Mexico, or South America. These areas are dealing with their own issues related to climate change and unsustainable farming practices that, coupled with supply chain uncertainties including fuel costs, may lead to higher food costs and possible shortages for Minnesotans. Moreover, produce grown far from its final consumers often necessitates practices like early harvesting leading to lower quality produce by the time it gets to its destination - especially rural Minnesota.

Objective:

The objective is to address several impact goal domains, namely: food systems, clean energy, adaptation, water and land, and environmental justice, by creating a model for sustainable food production in a shipping container. The solution is a containerized hydroponic growing system donated to the WCROC by Great River Energy outfitted with a solar array/battery system such that it operates as a Net-Zero food production system that could even operate off-grid. The solution will include a crop rotation and management plan that optimizes the strengths of containerized farming like producing high-value vegetables out of season and complete control of temperature and lighting conditions. The model will describe a sustainable, resilient, land and water efficient, energy neutral, and non-capital-intensive way to farm in the face of climate change - especially for folks that have often been left out of traditional farming.

The carbon footprint of the proposed model will be analyzed and compared to current alternatives. One goal is to create “The University of Minnesota Guidebook for Solar Powered Container Farming” that will contain lessons learned in this project and offer best practices.

Project Plan:

Container farming can address many issues in local food systems by eliminating the need for large land tracts and ideal weather conditions. The greatest barriers to more container farming

are initial capital requirements and high ongoing energy costs. The aim here is to combine a broad range of expertise in mechanical systems, energy systems, and horticulture science to develop a thorough model and demonstration of a solar powered container farming system. This project will be based in a rural area, but container farming is especially well-suited to urban settings. Therefore, this project will also help address concerns about urban agriculture, which according to a recent study has been found to have a carbon footprint six times higher than that of conventional agriculture (Hawes et al., 2024).

This project will involve four primary tasks:

1. Assess market conditions, farmer demographics, and food security issues for local foods in the Morris community and develop a strategic plan for future low-carbon, local foods.
2. Develop a crop selection and management plan for container farming including low energy protocols for off-grid operation.
3. Monitor container inputs and outputs while implementing the crop plan and design a solar/battery system sized for the container's energy needs and adapted to its structure.
4. Produce a comprehensive guidebook detailing project results and providing an accessible blueprint for any aspiring farmer/business owner.

Task 1: The State of Local Food

The City of Morris is in Stevens County in west central Minnesota about 150 miles from the Twin Cities Metro. Morris is, therefore, a tertiary market for common grocery goods. Local produce is only available seasonally at farmers' markets, but not in quantities that could serve the whole community - especially in the event of a food supply chain disruption.

Rural food security and availability are areas already being addressed by project community partners. Syd Bauer and Vern Simula are members of a local organization called the West Central MN Climate Network. The network is engaged in "The Morris/Stevens Community Local Food Security Project," which also interfaces with the rural food systems initiative on the UMN Morris campus. Funds from this solar powered container project will be used to hire an undergraduate intern to assist their local food system workgroup investigate the current local food system and develop a "revised" local food system that is less reliant on long-distant supply chains, provides our community with local healthy foods, and provides more entrepreneurial or employment opportunities - especially for the local Hispanic community. Professor Ed Brands (U. of MN Morris) who has expertise in sustainable food systems and led the project team that produced the Stevens County Food Assessment in 2022 (Brands et al., 2024) and the West Central MN Food Assessment (Brands et al., 2025) will lead this effort.

According to the Stevens County Food Assessment survey, approximately one-third of respondents were to some degree experiencing food insecurity. This proportion was closer to one-half of respondents in the more recent West Central MN Food Assessment that covered Douglas, Grant, Pope, Stevens, and Traverse counties. Recommendations and areas for further exploration identified in the food assessments include working with appropriate community partners and stakeholders to identify and implement ways of addressing community and individual food security needs that are acceptable to community residents and feasible within the context of our county and region's resources, location, and climate. That work will be started with this Solar Powered Container Farming project. Relevant community needs identified in the recent assessments included:

- Improve access to affordable food/groceries
- Provide transportation and/or reduce distance to food retailers
- Increase the availability of culturally appropriate foods and options for people with

specialized diets
- Facilitate more locally grown fresh produce and make produce more available to Stevens County and West Central MN residents

Another important part of this project is to determine how food from a solar powered container farm compares economically to food from existing container farms and how it would fit into the current local food system. Another undergraduate student intern working with Dr. Brands will search the literature and survey commercial operations, similar in scale to this proposal, to determine the current state of container farming. Particular attention will be paid to capital and operating costs, energy usage, and the type and value of crops grown. If possible, the team is prepared to install energy monitoring systems in local commercial container farms to better understand the major drivers of energy costs.

Task 2: Crop Selection and Management Plan

The economic viability of a stand-alone containerized farm is a key objective to this project thereby making crop selection a critical component to project success. Crop and cultivar selections will include those that are ideally suited to an indoor growing environment, offer some market advantage due to traditional seasonal availability and quality, deconvolute distribution channels, and/or offer some production advantage due to complete control of the growing environment. Novel growing systems, including hydroponic or aeroponic techniques that can readily adapt to multiple crops, will increase business diversity and system resiliency. Flexibility in crop selection and growing techniques will better enable a container farming system to adapt to changing market conditions. Moreover, these systems will reduce water and fertilizer use, decrease crop maturation time, and maximize space use efficiency. Here the project team will benefit from the horticulture and plant science expertise of Professor Nathan Eylands (U. of MN) and Dr. Joel Tallaksen (WCROC).

A unique consideration for a solar powered container farm is the energy burden of selected crops, i.e. lighting, water, temperature, and nutrient requirements. A solar powered container that is not tied to the electric utility grid will need to conserve battery power during times of extended low solar insolation - especially during winter. Low energy crop management protocols will be developed, in addition to peak energy optimization protocols, to help maintain an energy balance between solar energy collected/stored and the container energy load when needed. For example, operating electric lamps as the sole-source of plant photosynthetic radiation is energetically costly and can total 65 – 85% of total electrical inputs in sole-source farms (Arcasi et al., 2024). Therefore, implementing a lighting strategy with a focus on increasing light-use efficiency and maintaining a continuously closed canopy to improve photon capture can lower per unit production economics. Beneficial lighting strategies will include: 1. frequent plant-density adjustments, 2. pulsed LED duty cycle, and 3. spectral manipulation to facilitate biomass accumulation (Eylands and Mattson, 2023; Lubna et al., 2022).

Task 3: Operate Container Farm & Design a Suitable Solar/Battery System

A commercial container outfitted for food production -- Grow Pod Solutions Hydro Pod – was donated to the WCROC after its use in an energy study conducted for Great River Energy was concluded. Energy use in the grow pod is high due to the large number of LED lights needed for growing plants indoors and managing the resulting heat load.

Designing the container farm to be solar powered will require more attention and analysis to minimize the container energy load. The expertise of Professors Uwe Kortshagen (U. of MN) and Vivian Ferry (U. of MN) will provide detailed modeling of solar energy production to optimize panel mounting angles for seasonal energy production and structural integrity while also accounting for typical weather patterns in Morris. For example, panels can be mounted at a

steeper angle on the south side of the container to increase winter solar energy production while using the container as a wind block from prevailing north winds. Panels on the roof of the container can be mounted at a shallower angle increasing summer solar energy production and decreasing exposed wind loading. Initial estimates suggest a 40-foot shipping container could support a solar array of about 15 kW.

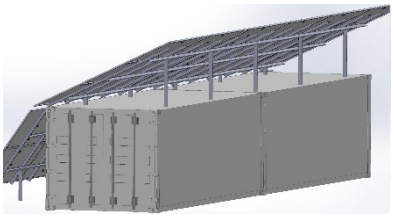

Figure 3. Generic Container w/Solar Array

Kortshagen and Ferry have done extensive work on modeling the environmental conditions, energy demands for cooling and heating, crop yield (for bib lettuce), and economic analysis for photovoltaic greenhouses. (Keil et al., 2021; Liu et al., 2023; Loh et al., 2024). The modeling framework can readily be adapted to a solar powered container farm. The model relies on meteorological and solar resource data that are imported from the NASA Power database - 10 years to get meaningful statistical averages. The environmental modeling module solves energy and mass balances for air and humidity. Compared to the greenhouse situation, the model will be modified to account for opaque, insulated walls, the heat generated by LED light sources, as well as the evaporation from growing crops. The model calculates average heating and cooling loads throughout the year and ventilation loads to maintain controlled humidity. The heating and cooling loads provide design parameters required to appropriately size the solar array and battery storage capacity.

The greenhouse model also includes an economic analysis module based on the widely used net present value (NPV) analysis. Our economic decision-making tool will be based on the net present value (NPV) analysis (Hollingsworth et al., 2020). The NPV is calculated as the sum of the discounted revenue over time, assuming a lifetime of 30 years.

Eric Buchanan (WCROC) and the Renewable Energy Program staff have gained significant experience designing and installing solar arrays and off-grid battery systems including the design of unusual solar panel mounting structures for mobile solar power stations. The WCROC also has relevant expertise with heat pumps, automation/robotics, and general electromechanical systems.

A set of engineering drawings will be produced for a unique solar panel container mounting system and included in a solar powered container farm guidebook.

Task 4: Life Cycle Assessment

Conventional greenhouses use a significant amount of heat energy for cool season vegetable production (Dias et al., 2017). Typically, this energy is fossil-fuel based. The meta-analysis by Clune et al. (2017) found that conventional greenhouse production often emitted several times more carbon dioxide than field grown produce, mainly from heating energy use.

To date, very little life cycle assessment (LCA) work has been done on containerized systems. In Michigan, an analysis of season extending double-walled hoop houses found that low-tech structures could save significant energy and emissions when compared with lettuce produced and shipped from the southern United States (Plawecki, et al., 2014). However, these studies have not included specially designed container farms as proposed here.

Life cycle assessment is a technique that is well-suited for examining the environmental impacts of the inputs and processes needed for complex production systems, including food production. The LCA for this project will examine water and energy impacts of regionally grown fresh produce in the context of a variety of different production methods (Clune et al., 2017). Areas where energy, water, and greenhouse gas impacts can be minimized while increasing productivity will be identified. The LCA will include analyses of a base case and numerous

alternative scenarios for examining design and operational enhancements, and it will also compare cool-climate food production in container farms to reference systems based on produce shipped from other locations. Energy and water impacts will be examined in the direct and indirect (embedded) resources needed for container farm food production, including: 1) structural materials and mechanical operation; 2) production method(s); and 3) the produce supply chain moving produce to market.

Outcomes and Impact:

Minnesota Governor Tim Walz's administration created a Climate subpanel which in turn created the "Minnesota's Climate Action Framework". The Framework includes ambitious goals and will be used to work with all stakeholders to build solutions reflecting the urgency of climate change for all Minnesotans. The Framework is organized around six broad goals: Clean transportation, Climate-smart natural and working lands, Resilient communities, Clean energy and efficient buildings, Healthy lives and communities, and a Clean economy.

Solar powered container farming has the potential to positively impact all of these goals by reducing the need for long distance transportation of food, reducing pressure on land for more food production, adding to local resilience by providing local food production, demonstrating a novel use of solar energy, increasing community health with local, fresh food, and providing a model for low carbon food production accessible to entrepreneurs.

The Minnesota Climate Action Framework goals dovetail nicely with the IonE Impact goal domains this project addresses: Food Systems, Adaptation, Clean Energy, Water and Land, and Environmental Justice.

The primary deliverable from this project (in addition to academic papers) will be a guidebook detailing specifications for constructing a solar powered container farm: "The University of Minnesota Guidebook for Solar Powered Container Farming". The guidebook will be freely available on multiple University websites and include results from the project team's extensive analyses on container farming crop selection, operational management including low energy protocols, energy usage, lighting, HVAC, energy production, and energy storage. Engineering drawings will also be included for solar panel attachment. Results from marketing surveys about existing rural food supply chains and demographics will be highlighted with advice on how a farmer might position their low carbon, container grown produce for market success.

The analytical results from this project will provide the necessary background information to successfully apply for an LCCMR grant to fund the addition of the energy system to container farm on the WCROC campus. A solar powered container farm would add to the current suite of unique agrivoltaic demonstrations and enhance the Center's mission of leading innovation in agriculture. A solar powered container farm would feature prominently in the numerous renewable energy tours conducted at the WCROC for over 300 people annually and be featured in the Midwest Farm Energy Conference hosted biennially at the WCROC.

Project results will be further communicated by our community partners, the Morris Model and the West Central MN Climate Network in coordination with the rural food systems initiative on the UMMorris campus.

Project Management

Growing high value crops in shipping containers provides an opportunity to concentrate food production in a smaller area that is independent of geographical and weather constraints. If the container is sufficiently insulated and outfitted with a solar array, it may even produce enough energy to be an attractive business opportunity for urban dwellers or rural farmers without access to large tracts of land. Also, there is an ever-increasing desire by consumers and restaurants for locally grown food - especially in winter.

A successful project will require optimizing many factors simultaneously such as crop selection and management for profitable economics, crop energy burden, solar production and energy storage, frugal equipment selection and container modifications, and maximizing production with efficient use of space. All while meeting local market conditions and desires.

Overall project leadership will be provided by Eric Buchanan (WCROC) and managed through, at a minimum, monthly project team meetings. Mr. Buchanan and his staff will also lead the efforts in task 3 to design a solar panel mounting system and monitor energy usage. The WCROC will hire a full-time person to manage growing operations in the grow pod with Kent Peterson, a local commercial hydroponic farmer, as a consultant. The renewable energy staff will also coordinate with the ME4054 class for a senior capstone project and supervise an undergraduate intern to help with these tasks.

Professor Uwe Kortshagen (MechEng) and Professor Vivian Ferry (CEMS) will lead the solar energy, thermal, and economic modeling efforts of task 3.

Professor Nathan Eylands (Hort) will lead task 2 developing the crop selection management strategies in partnership with Kent Peterson.

Dr. Joel Tallaksen (WCROC) will lead task 4 performing Life Cycle Analyses of the proposed container farm under various operational scenarios and comparing them with the current long-distance shipping options. He will also collaborate on task 2.

Professor Ed Brands (UMM) will lead task 1 coordinating with community partners Syd Bauer (WCMNCN), Vern Simula (WCMNCN), and Kent Peterson (Bees and Greens, Benson, MN) to conduct surveys examining the current state of the Morris community food systems and the potential impact of solar powered container farming, conduct marketing studies on the current state of small farm container farming and potential strategies for farmers to market the products of a solar powered container farm. Dr. Brands will supervise two undergraduate interns to aid with these tasks and coordinate additional projects/farming/educational activities with UMM students in an ongoing partnership between UMM and the WCROC.

All food produced during this project will be donated to the Stevens County Food Shelf, Morris Area Schools cafeteria, or UMM Food Services.

Citations

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Brands E, Manolis A, Kenyon D, Sugimura L, Koos A. (2024). Food Security and Desertification: A West-Central Minnesota Case Study. *Journal of Food Security.* .12(1): 1-12.

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Eylands NJ, Mattson NS. (2023). Influence of far-red intensity during the seedling stage on biomass production and photomorphogenic characteristics in leafy greens under sole-source lighting. *Horticulturae.* 9: 1100. https://doi.org/10.3390/horticulturae9101100.

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Keil, J., Liu, Y., Kortshagen, U., Ferry, V.E., 2021. Bilayer Luminescent Solar Concentrators with Enhanced Absorption and Efficiency for Agrivoltaic Applications. ACS Applied Energy Materials 4, 14102–14110. https://doi.org/10.1021/acsaem.1c02860

Liu, Y., Keil, J., Ferry, V.E., Kortshagen, U.R., 2023. Energy and Thermal Performance Analysis of Quantum Dot Luminescent Solar Concentrators in Greenhouses. Advanced Sustainable Systems 2300107. https://doi.org/10.1002/adsu.202300107

K. Q. Loh, K. Harbick, N. J. Eylands, U. R. Kortshagen, V. E. Ferry, Design Guidelines for Luminescent Solar Concentrator Greenhouses in the United States. Adv. Sustainable Syst. 2025, 9, 2400749. https://doi.org/10.1002/adsu.202400749

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different fresh food categories. Journal of Cleaner Production, 140, Part 2, 766-783.
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Plawecki, R., Pirog, R., Montri, A., & Hamm, M. W. (2014). Comparative carbon footprint assessment of
winter lettuce production in two climatic zones for Midwestern market. Renewable Agriculture and
Food Systems, 29(04), 310-318.

ERIC BUCHANAN

4 Circle Pines, Morris, MN 56267
(320) 589-1686 buch0123@morris.umn.edu

EDUCATION

Bachelor of Science degree in Aerospace Engineering from Purdue University, December 1988

SUMMARY OF QUALIFICATIONS

- Demonstrated ability to creatively solve engineering problems – 11 US patents
- Proven leadership skills as an engineering supervisor and project manager - 36 years of experience in the aerospace, automotive, medical device, and renewable energy industries
- Excellent oral and written communication skills – submitted reports to granting and government regulatory agencies. Author/Co-author on 8 journal papers and 3 posters

PROFESSIONAL EXPERIENCE

4/10 to present **University of Minnesota West Central Research and Outreach Center, Morris, MN**

Renewable Energy Scientist leading grant funded projects as Principal Investigator including budget management and grant reporting. Also responsible for evaluation, testing and optimization of small-scale renewable energy systems. Develop new project ideas and aid in preparing grant proposals. Provide guidance and oversight to junior scientists and interns.

9/02 to present **Morris Area High School, Morris, MN**

Head coach of FIRST Robotics, Knowledge bowl, Math League, and JH Tennis teams. Taught algebra for the '03/'04 school year and biology for part of '06.

4/96 to 5/01 **St. Jude Medical, St. Paul, MN**

Supervisor and team leader for other engineers and project teams. Created novel concepts for new bovine tissue heart valves and rapid attachment of mechanical heart valves. Designed, built and tested prototype devices including demonstration of prototypes to cardiovascular surgeons worldwide.

10/93 to 4/96 **Morton International, Ogden, UT**

Developed new concepts for a next generation airbag system. Responsible for concept inception, performance calculations, engineering documentation and demonstrating the feasibility and manufacturability of proposed designs. Also assisted in the presentation and marketing of the new system to automobile manufacturers worldwide.

6/89 to 10/93 **Thiokol Corporation, Brigham City, UT**

Directed all engineering activities and acted as principle customer interface for the Space Shuttle Advanced Solid Rocket Motor (ASRM) Nozzle program. Managed schedules and $3 million budget, approved all engineering documents, prepared proposals, and assisted in contract negotiations.

ERIC BUCHANAN

4 Circle Pines, Morris, MN 56267
(320) 589-1686 buch0123@morris.umn.edu

REFEREED PAPERS

Sharpe K.T., Heins B.J., Buchanan E.S., & Reese M.H., (2021). Evaluation of solar photovoltaic systems to shade cows in a pasture-based dairy herd. Journal of Dairy Science, 104(3), 2794-2806.

Zhu, Y., L. J. Johnston, M. Reese, E. Buchanan, J. Tallaksen, A. Hilbrands, and Y. Z. Li. 2021. Effects of cooled floor pads combined with chilled drinking water on behavior and performance of lactating sows under heat stress. J. Anim. Sci. 99(3). doi.org/10.1093/jas/skab066

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Sharpe, K. T., M. H. Reese, E. S. Buchanan, J. E. Tallaksen, K. A. Janni, and L. J. Johnston. 2018. Electrical and thermal energy consumption in Midwest commercial swine facilities. Appl. Eng. Agric. 34(5):857-864. (doi:10.13031/aea.12771)

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Reese, M., Marquart, C., Malmali, M., Wagner, K., Buchanan, E., McCormick, A., and Cussler, E.L. (2016) Performance of a Small-Scale Haber Process. Ind. Eng. Chem. Res., 55(13), pp 3742-3750.

Heins, B., Tallaksen, J., Reese, M., Buchanan, E. (2016) Life Cycle Energy and Greenhouse Gas Comparison of Co-located Organic and Conventional Dairy Systems. Journal of Animal Science 94 (supplement 5):571

INVITED PAPERS AND ACADEMIC PRESENTATIONS

Buchanan, E. *Strategic Farm Electrification: The E-Farm*. Midwest Rural Energy Council. MPLS, MN. February 2025.

Buchanan, E. *Future Farming: The E-Farm*. Midwest Farm Energy Conference. Morris, MN. June 2024.

Buchanan, E. *Emerging Agrivoltaic Applications for Midwest Farms*. American Solar Energy Society Annual Conference. Boulder, Co. August 2023.

Buchanan, E. *Farm Electrification*. Midwest Farm Energy Conference. Morris, MN. June 2022.

Edwin Brands

Education

Degree	Institution	Date Degree Granted
BA	Grinnell College Biology/German	1996
MA	The University of Iowa Geography	2002
PhD	The University of Iowa Geography (Advisor: R. Rajagopal)	2004

Personal Statement

I am an Associate Professor of Environmental Studies with broad training in environmental geography, wide-ranging teaching experiences (more than 20 unique courses taught) spanning the physical and social sciences, 15 years of experience coordinating internships, and more than 10 years of experience coordinating interdisciplinary environmental programs at liberal arts institutions. My research focus has shifted over the years but has remained in the context of agricultural impacts on water quality and food production, beginning with my dissertation work on drinking water quality in Iowa cities reliant upon surface water and most recently on assessing community food security in Stevens County MN and surrounding counties. I use a variety of research methods, including surveys which have been an important part of food security assessment work as well as a recent evaluation of our local organics recycling (composting) program. I also have extensive experience collaborating with community partners and various aspects of the University system through recent research, teaching, and curriculum development initiatives.

Professional Experience

University of Minnesota, Morris Associate Professor, Coordinator of Environmental Studies	2015-
University of Minnesota, Morris Assistant Professor of Environmental Studies	2011-2015
Birmingham Southern College Assistant Professor of Geography and Coordinator of Urban Environmental Studies	2008- 2011

Recent Grants

Project Co-Director (Morris Campus) Development of an organic agriculture curriculum with emphasis on animal production for undergraduate and graduate students. USDA Organic Research Education and Extension Initiative. Project Director: Y. Li, Co-Director B. Heins (UMN WCROC), Co-Director A. Johny (UMN St. Paul Campus). $750,000.

Center for Urban and Regional Affairs, Faculty Interactive Research Program. Regional Food Assessment-West Central Minnesota. Co-Investigator Dr. Cristina Ortiz. (July 2023-June 2024). $44,666.

Faculty leader (Morris Campus) ACS Mellon Grant, Environmental Stewardship (UMTC, Duluth, Morris campuses) 2019-2020. $1,077,000

Recent Publications

Refereed Journal Articles

Brands E, Manolis A, Kenyon D, Sugimura L, Koos A. (2024). Food Security and Desertification: A West-Central Minnesota Case Study. *Journal of Food Security.* Accepted for publication March 2024.

Brands, E. and R. Rajagopal. 2018. Which Water to Drink? Costs and Benefits of Alternatives. *SF J Pub Health. 2(1).*

Brands, E. 2014. Prospects for Sustainable Sanitation in Developed Nations: A Critical Review. *Environmental Reviews.* 22(4): 346-363. doi: 10.1139/er-2013-0082.

Brands, E. 2014. Siting restrictions and proximity of Concentrated Animal Feeding Operations to surface water. *Environmental Science & Policy.* 38: 245-253.

Professional Projects and Reports

Brands, E. Marks, C. 2023. Stevens County Organics Recycling Program (local survey, literature review). April 2023.

Brands E., Kenyon D., Koos A., Sugimura L., Manolis A. 2022. Stevens County Food Assessment. Center for Community Partnerships. University of Minnesota Morris. 96.p. https://morris.umn.edu/center-small-towns/stevens-county-food-assessment.

Brands, E. Nace, K, Noe-Hays, A. et al. 2018. Urine Diversion and Reuse: Advancing the Agenda in the United States. Rich Earth Institute, Brattleboro, VT.

Recent Invited Presentations (selected)

"Stevens County Food Assessment" State of Minnesota Cross Agency Work Group Group-Jan 24, 2024

"Food Assessment in a Rural Context-Stevens County, MN" University of Minnesota Rural Collaborative. April 25, 2023.

"The Stevens County Food Assessment and Emergency Food." Invited lecture/discussion and extended interaction with software design and development course. Spring semester 2023.

"Food Assessment in a Rural Context-Stevens County, MN." University of Minnesota Day of Data. January 11, 2023.

Nathan Jon Eylands, Ph.D.
Assistant Professor; Controlled Environment Agriculture
Gardner-Kivnick Professorship in Controlled Environment Horticulture

1. Contact Information:

Department of Horticultural Science, University of Minnesota
1970 Folwell Ave., St. Paul, MN 55108
Email: neylands@umn.edu
Phone: (406) 579-0553

2. Education and Training

Dec. 2022	Doctor of Philosophy, Horticultural Biology, Cornell University
Dec. 2018	Master of Science, Horticulture, University of Arkansas
May 2008	Bachelor of Science, Ecology, Montana State University

3. Research and Professional Experience:

3/2023 - Present	Assistant Professor, Horticultural Science, University of Minnesota
1/2019 – 12/2022	Graduate Research Assistant, Cornell University
1/2017 – 12/2018	Graduate Research Assistant, University of Arkansas
6/2014 – 1/2019	Operations Manager, Ozark All Seasons Leafy Greens

4. Awards and Honors

2023	Gardner-Kivnick Endowed Professorship in Controlled Environment Horticulture
2022	American Society for Horticultural Science Honorable Mention Oral Competition
2021	American Society for Horticultural Science 2nd Place Oral Competition
2020	Pi Alpha Xi National Honor Society – Alpha Chapter
2020	Department of Energy Honorable Mention Poster Competition
2020	American Society for Horticultural Science Honorable Mention Oral Competition

5. List of Publications Related Most to the Proposed Project:

- Veazie, P., Chen, H., Hicks, K., Holley, J., **Eylands, N.J.**, Mattson, N.S., Boldt, J., Brewer, D., Lopez, R., and Whipker, B.E. 2024. A data-driven approach for generating leaf tissue nutrient interpretation ranges for greenhouse lettuce. HortScience 59(3):267-277. doi: https://doi.org/10.21273/HORTSCI17582-23.
- **Eylands, N.J.** and N.S. Mattson. 2023. Influence of far-red intensity during the seedling stage on biomass production photomorphogenic characteristics in leafy greens under sole-source lighting. Horticulturae. 9(10):1100. doi: https://doi.org/10.3390/horticulturae9101100.
- **Eylands, N.J.**, M.R. Evans, and A.M. Shaw. 2021. Antimicrobial mitigation via saponin intervention on *Escherichia coli* and growth and development of

hydroponic lettuce. HortTechnology 31(2):174-180. doi: https://doi.org/10.21273/HORTTECH04749-20.

VIVIAN E. FERRY
Associate Professor of Chemical Engineering and Materials Science

University of Minnesota
421 Washington Ave SE
Minneapolis, MN 55455

Email: veferry@umn.edu
Tel: 612-625-7522
Web: research.cems.umn.edu/ferry

Education

2011	Ph.D. Chemistry, California Institute of Technology (H. A. Atwater)
2006	S. B. Chemistry, University of Chicago

Research and Professional Experience

2021 – 2024	*George T. Piercy Professor*
2020 –	Associate Professor, CEMS, University of Minnesota
2017 – 2019	*McKnight Land-Grant Assistant Professor*
2014 – 2020	Assistant Professor, CEMS, University of Minnesota
2011 – 2014	Postdoctoral Scholar, Lawrence Berkeley National Laboratory (A. P. Alivisatos)

Recent Honors and Awards

2021	Fellow, Institute on the Environment, University of Minnesota
2020	SPIE Early Career Achievement Award
2019	Marion Milligan Mason Award in the Chemical Sciences, AAAS
2019	American Physical Society Ovshinsky Sustainable Energy Fellowship
2016	35 Innovators under 35, Technology Review
2016 - 2021	National Science Foundation CAREER Award
2016 - 2019	Air Force Office of Scientific Research Young Investigator Award

Selected Relevant Publications

[§]*Corresponding author*

10. **V. E. Ferry**[§], "Luminescent solar concentrator PV: technology status," in *Status Report on Emerging Photovoltaics, Journal of Photonics for Energy* (2023). https://dx.doi.org/10.1117/1.JPE.13.4.042301.

9. Y. Liu, J. Keil, **V. E. Ferry**, U. R. Kortshagen[§], "Energy and thermal performance analysis of quantum dot luminescent solar concentrators in greenhouses," *Advanced Sustainable Systems*, 7, 8, 2300107 (2023). https://doi.org/10.1002/adsu.202300107

8. J. Keil*, Y. Liu*, U. Kortshagen, **V. E. Ferry**[§], "Bilayer luminescent solar concentrators with enhanced absorption and efficiency for agrivoltaic applications," *ACS Applied Energy Materials*, 4, 14102 – 14110 (2021). https://doi.org/10.1021/acsaem.1c02860

7. B. M. Cote, I. M. Slauch, T. J Silverman, M. G. Deceglie, **V. E. Ferry**[§], "Light management in bifacial photovoltaics with spectrally-selective mirrors," *ACS Applied Energy Materials*, **4**, 6, 5397-5402 (2021). https://doi.org/10.1021/acsaem.1c01236

6. I. M. Slauch, M. G. Deceglie, T. J Silverman, **V. E. Ferry**[§], "Optical approaches for passive thermal management in c-Si photovoltaic modules," *Cell Reports Physical Science*, 2, 100430 (2021). https://doi.org/10.1016/j.xcrp.2021.100430

5. S. K. E. Hill, R. Connell, J. Held, C. Peterson, M. A. Hillmyer, L. F. Francis, **V. E. Ferry**[§], U. Kortshagen[§], "Poly(methyl methacrylate) films with high concentrations of silicon quantum dots for visibly transparent luminescent solar concentrators," *ACS Applied Materials and Interfaces*, **12**, 4, 4572 – 4578 (2020). https://doi.org/10.1021/acsami.9b22903
4. R. Connell, J. Keil, C. Peterson, M. A. Hillmyer, **V. E. Ferry**[§], "CdSe/CdS-poly(cyclohexylethylene) thin film luminescent solar concentrators," *APL Materials,* **7**, 101123 (2019). http://dx.doi.org/10.1063/1.5121441
3. S. K. E. Hill*, R. Connell*, C. Peterson, J. Hollinger, M. A. Hillmyer, U. Kortshagen[§], **V. E. Ferry**[§]**,** "Silicon quantum dot – poly(methyl methacrylate) nanocomposites with reduced light scattering for luminescent solar concentrators," *ACS Photonics,* 6, 170 – 180 (2019). http://dx.doi.org/10.1021/acsphotonics.8b01346
2. R. Connell, C. Pinnell, and **V. E. Ferry**[§]**,** "Designing spectrally-selective mirrors for use in luminescent solar concentrators," *Journal of Optics,* 20, 024009 (2018). *(Special Issue: Emerging Leaders).* https://doi.org/10.1088/2040-8986/aaa074
1. R. Connell and **V. E. Ferry**[§], "Integrating photonics with luminescent solar concentrators: optical transport in the presence of photonic mirrors," *J. Phys. Chem. C*, 120, 20991 – 20997 (2016). http://dx.doi.org/10.1021/acs.jpcc.6b03304

Selected Synergistic Activities

- Leader, IRG-1 Ionic Control of Materials, UMN MRSEC, 2022 – present.
- Editorial board member, Journal of Physical Chemistry, 2023 – present.
- Editorial board member, ACS Applied Optical Materials, 2022 – present.
- Associate editor, Optics Express, 2022 – 2025.
- Member, Publications Committee, SPIE, 2023 – 2026.
- Editorial board member, PRX Energy, 2021 – present.
- Member, National Security Institute Task Force, University of Minnesota, 2023.
- Organizer, Eureka! Camp session on optical materials, University of Minnesota, July 2023.
- Vice-chair, Optical Society of America Technical Group Optics for Energy, 2014 – 2017; 2018 – 2021.
- Co-Chair, Area 1 (Fundamentals and new concepts for future technologies), IEEE Photovoltaics Specialists Conference, 2022.
- Co-Chair, Green photonics, Photonics North, 2021.
- Sub-Area Chair, Advanced light management and spectral shaping, Fundamentals and new concepts for future technologies, IEEE Photovoltaics Specialists Conference, 2021.
- Congressional briefing, "Understanding the potential of solar energy: tackling energy challenges of tomorrow." Presented a summary of Chemical Sciences and Society white paper to congressional staffers, coordinated by the American Chemical Society, Washington DC, September 2018.
- Member, US Delegation to the Chemical Sciences and Society Summit on Solar Energy and Photonics, Dalian, China, 2017. *Member of a 5-person team coordinated by the American Chemical Society.*

Uwe Richard Kortshagen, Ph.D.
Ronald L. and Janet A. Christenson Chair in Renewable Energy
Distinguished McKnight University Professor

1. Contact Information:

Department of Mechanical Engineering, University of Minnesota
111 Church Street S.E., Minneapolis, MN 55455
Email: Kortshagen@umn.edu
Phone: (612) 625-4028

2. Education and Training:

Nov. 1995	Habilitation in experimental physics, Ruhr-University Bochum, Germany.
Jan. 1991	Dr. rer. nat. (Ph.D.) in Physics, Ruhr-University Bochum, Germany.
June 1988	Dipl. Phys. degree in Physics, Ruhr-University Bochum, Germany.

3. Research and Professional Experience:

7/2019 – present:	Ronald L. and Janet A. Christenson Chair in Renewable Energy
7/2008 – 12/2018:	Head, Department of Mechanical Engineering, University of Minnesota
7/2015 – 12/2018:	James J. Ryan Professor of Mechanical Engineering
7/2007- present:	Distinguished McKnight University Professor
8/2006- 6/2008:	Director of Graduate Studies, Dept. of Mechanical Eng., University of Minnesota
8/2003- present:	Professor, Mechanical Engineering, University of Minnesota
8/1999 – 8/2003:	Associate Professor, Mechanical Engineering, University of Minnesota.
7/1996 – 8/1999:	Assistant Professor, Mechanical Engineering, University of Minnesota.
4/1996 - 7/1996:	Lecturer, Dept. of Physics and Astronomy, University of Bochum, Germany.
3/1995 – 3/1996:	Visiting scholar, University of Wisconsin - Madison, Dept. of Physics.
6/1988 – 3/1995:	Research Associate, Dept. of Physics and Astronomy, University of Bochum.

4. Awards and Honors:

2023 Univ. of Minnesota George Taylor Award for Distinguished Teaching
2020 Fellow, Institute on the Environment, University of Minnesota
2019 Ronald L. and Janet A. Christenson Chair in Renewable Energy
2018 Fellow, American Physical Society
2015 Plasma Prize, American Vacuum Society
2015 James J. Ryan Professor of Mechanical Engineering
2013 Fellow, International Plasma Chemistry Society
2009 Fellow, American Society of Mechanical Engineers
2008-09 President, International Plasma Chemistry Society
2003-11 Member of the Board of Directors, International Plasma Chemistry Society
2007 Distinguished McKnight University Professor
2005 Univ. of Minnesota - George Taylor Award for Distinguished Research
2004 Fellow, Institute of Physics (U.K.)
1999 NSF Career Award
1997 Director, NATO Advanced Research Workshop
1997 Mayhugh Assistant Professor

5. List of publications related most to the proposed project

Full list: https://scholar.google.com/citations?user=nEgoYssAAAAJ&hl=en

(> 240 peer-reviewed publications, h-index 69)

- "Energy and Thermal Performance Analysis of Quantum Dot Luminescent Solar Concentrators in Greenhouses," Liu, Y.; Keil, J.; Ferry, V. E.; Kortshagen, U. R. *Advanced Sustainable Systems*, 2300107 (2023). https://doi.org/10.1002/adsu.202300107.
- "Bilayer Luminescent Solar Concentrators with Enhanced Absorption and Efficiency for Agrivoltaic Applications." Keil, J., Liu, Y., Kortshagen, U., Ferry, V.E. *ACS Applied Energy Materials* **4 (12)**, 14102–14110 (2021). doi:10.1021/acsaem.1c02860
- "Poly(Methyl Methacrylate) Films with High Concentrations of Silicon Quantum Dots for Visibly Transparent Luminescent Solar Concentrators," Hill, S. K. E., Connell, R., Held, J., Peterson, C., Francis, L., Hillmyer, M. A., Ferry, V. E., and Kortshagen, U. *ACS Applied Materials & Interfaces* **12**, 4572–4578 (2020). doi:10.1021/acsami.9b2290310.
- "Silicon quantum dot-poly (methyl methacrylate) nanocomposites with reduced light scattering for luminescent solar concentrators," Samantha Hill, Ryan Connell, Colin Peterson, Jon Hollinger, Marc A Hillmyer, Uwe R Kortshagen, Vivian E Ferry, *ACS Photonics* **6**(1), 170-180 (2019).
- "Evaluating Tandem Luminescent Solar Concentrator Performance Based on Luminophore Selection.," Keil, J., Liu, Y., Kortshagen, U., Ferry, V.E. 2021 IEEE 48th Photovoltaic Specialists Conference (PVSC). 1680–1684 (2021).
- "Highly efficient luminescent solar concentrators based on earth-abundant indirect-bandgap silicon quantum dots," Meinardi, F.; Ehrenberg, S.; Dhamo, L.; Carulli, F.; Mauri, M.; Bruni, F.; Simonutti, R.; Kortshagen, U.; Brovelli, S., *Nat Photon*, **11 (3)**, 177-185, (2017).
- "High-Yield Plasma Synthesis of Luminescent Silicon Nanocrystals", L. Mangolini, E. Thimsen and U. Kortshagen, *Nano Lett.* **5** , 655-659, (2005). 10.1021/nl050066y

6. Synergistic Activities

- Department Head, Mechanical Engineering, University of Minnesota, 2008-2018
- Board of Directors, International Plasma Chemistry Society, 2003-2011. Vice President, 2006-2007. President, 2008-2009
- Gordon Research Conference on Plasma Processing Science, Chair 2010, Vice Chair 2008; Gordon Research Conference on Nanomaterials for Applications in Energy Technology, Founding Vice Chair, 2013; Chair 2015
- Member of Editorial Boards for Plasma Sources Science and Technology; Contributions to Plasma Physics; Nanomaterials
- ASME Department Head Executive Committee, 2009-2015; Secretary, 2011-12; Vice Chair, 2012- 13; Chair, 2013-14; Past Chair 2014-15

Joel Tallaksen, Ph.D.

Ag and Energy Scientist

West Central research and Outreach Center
College of Food, Science, and Natural Resource Sciences
University of Minnesota

46352 State Highway 329
Morris, MN
(612) 382-2517 tall0007@umn.edu

Professional Profile

- Over 30 years' experience in agricultural and plant production systems.
- Ability to organize and direct complex projects from concept to operation.
- Able to quickly adapt to new situations and work with new information.
- Proven ability to work in unison with researchers, practitioners, and the public.

Education

Ph.D, Plant Biological Sciences, University of Minnesota, 2002

Dissertation "Nutrient and Arbuscular Mycorrhizal Amendments in Prairie Restoration"

B.S. Plant Biology, Genetics & Cell Biology, University of Minnesota, 1993.

Active Research Areas

My current research is focused on transforming agricultural production by examining energy use and integrating innovative energy systems. I am using life cycle analysis (LCA) as a tool to determine the amount of energy needed and greenhouse gases emitted in a variety of livestock and cropping systems and how renewable energy improves these systems. My short-term goal is to optimize energy use in farm production to create systems that are very productive but use fewer fossil energy resources. My ultimate objective is to incorporate renewable energy systems in all aspects of farm operations, crafting highly productive systems that are not reliant on fossil fuels. Yet, my optimization efforts extend beyond energy efficiency, incorporating a holistic approach that prioritizes sustainable harvesting practices, soil health, and economic viability.

Recent Writings, Presentation and Outreach Information

- Y. Zhu, L. J. Johnston, M. Reese, E. Buchanan, J. Tallaksen, A. Hilbrands, and Y. Z. Li. (Accepted) Effects of cooled floor pads combined with chilled drinking water on behavior and performance of lactating sows under heat stress, J. Anim. Sci.
- Cortus, E., Johnston, L., Tallaksen, J., DeWitte, D., Schiek, S., Brian Hetchler, . . . Schmidt, A. 2020. *Environmental Footprints for Regional Swine Production Systems Now and in the Future: Carbon and Water Footprints for Local Pig Farms – Current Baselines and Opportunities for Communication and Change*. (Research findings report for farm cooperators/stakeholders- available on request)
- Zhu, Y., Li, Y., Reese, M., Buchanan, E., Tallaksen, J., & Johnston, L. (2020). Behavior and Performance of Suckling Piglets Provided Three Supplemental Heat Sources. *Animals, 10*(7), 1155.
- Tallaksen, J., Johnston, L., Sharpe, K., Reese, M., & Buchanan, E. 2020. Reducing life cycle fossil energy and greenhouse gas emissions for Midwest swine production systems. J. of Cleaner Production, 246, https://doi.org/10.1016/j.jclepro.2019.118998
- Cortus, E., Johnston, L., Tallaksen, J., DeWitte, D., Schiek, S., Brian Hetchler, . . . Schmidt, A. 2019. *Environmental Footprints for Regional Swine Production Systems Now and in the Future – A*

Demonstration Pilot Project (NPB #18-042). Final Project Report. Retrieved from DesMoines, IA, US: https://www.pork.org/wp-content/uploads/2020/01/18-042-CORTUS-Final-Report.pdf

- Tallaksen, Joel E., Curtis Reese, Michael H Reese, 2019 Cropping System Fuel Use for a Diversified Farm in the Midwestern United States. Applied Engineering in Agriculture. 35(4): 503-507. https://doi.org/10.13031/aea.13326
- Palys, Matthew J., Anatoliy Kuznetsov, Joel Tallaksen, Michael Reese, Prodromos Daoutidis. 2019. A novel system for ammonia-based sustainable energy and agriculture: Concept and design optimization. Chemical Engineering and Processing - Process Intensification. V140, June 2019, pp. 11-21. https://doi.org/10.1016/j.cep.2019.04.005
- Sharpe, K. T., Reese, M. H., Buchanan, E. S., Tallaksen, J. E., Janni, K. A., & Johnston, L. J. 2018. Electrical and Thermal Energy Consumption in Midwest Commercial Swine Facilities. *Applied Engineering in Agriculture*, 34(5), 857-864.
- Tallaksen, J., Tuna, P., Bauer, F., Hulteberg, C., and Ahlgren, S. (2017) *Life Cycle Energy of Renewably Produced Nitrogen Fertilizers*, Final workplan (Report) for Minnesota Legislative and Citizens committee on Minnesota Resources, Project M.L. 2014, Chp. 226, Sec. 2, Subd. 08e, Submitted September 2017 by Joel Tallaksen, Project Manager
- Tallaksen, J. (2017) Sub-report- *Life Cycle Assessment of Swine Production* of Final workplan submitted to the Minnesota Legislative and Citizens committee on Minnesota Resources for Project M.L. 2014, Chp. 226, Sec. 2, Subd. 08d Transitioning Minnesota Farms to Local Energy, August 2017, Michael Reese, Project Manager
- Tallaksen, J., Bauer, F., Hulteberg, C., Reese, M., and Ahlgren, S., (2015) Nitrogen fertilizers manufactured using wind power: greenhouse gas and energy balance of community-scale ammonia production. *Journal of cleaner Production,* 107: 626-635 doi:10.1016/j.jclepro.2015.05.130

Recent Grant Funded Activities

USDA-NIFA $350,000 total funding, Spring 2020 to Spring 2022 (Project Director, 35% Commitment)
Improving alfalfa-based livestock forage production systems using life cycle assessment.

USDA-NIFA $500,000 total funding, Fall 2017 to Fall 2021 (Researcher, 10% commitment)
Breaking barriers to organic swine transition: Utilizing cover crops as feed ingredients to reduce feed cost.

Multiple sources, $2 million+ funding, 2015 to Winter 2020 (Co-PI, up to 80% commitment)
Participating with other researchers in a set of related projects collectively titled 'Greening of Agriculture'. The projects examined energy inputs and sustainability of agricultural systems by analyzing and enhancing actual on-farm energy use in the cropping, swine, and dairy systems at the West Central Research and Outreach Center.

CONTACT

Phone

(651) 395-0832

Email

syd.r.bauer@gmail.com

Address

11 Elm St. Morris, MN 56267

SKILLS

Enthusiastic & effective communicator
Highly organized
Relational Leader
"Capable of herding cats"
Systems thinker

VALUES

Safety, Snacks, Friendship
Play, Joy, Fun, Silliness
Process, Purpose
Intention, Accessibility
Conversation, Connection

SYD BAUER

is attempting to think before she acts

A SYD SUMMARY

Syd is a young Morris citizen with a drive to build accessible community, ask aspirational questions, and engage more deeply with their neighbors and friends. She hopes to spend time with others putting intentional thought into what it means to lead, build, and play in our communities.

ROLES

City of Morris Transit I 2018 - Present
Transit Driver
City-wide public transit system that promotes accessible, sustainable transportation. Serving large portions of our aging, disabled, immigrant and pre-k community!

Stevens County I 2021 - Present
Organics Recycling Program Coordinator
Leading county-wide efforts to increase opportunities, access, and education surrounding implementation of Organics Recycling throughout Stevens County.
www.co.stevens.mn.us/organics

West Central MN Climate Network I 2019 - Present
Co-Coordinator
A community group of neighbors focused on promoting individual and group action toward a resilient, equitable, and sustainable community through modeling behavioral change, conversation, and education.
westcentralmnclimate.network

ENGAGEMENT

Senior Meals Volunteer
Dance Party Coordinator
City Council Superfan
Engaged Neighbor & Community Member

Professional Career Bio

Vernon L. Simula, Ed.D.
Emeritus Professor of Education (1992)
University of Minnesota, Duluth

Education

1950 B.S., English Literature
University of Minnesota, Duluth

1960 M.A., School Administration
Northern Iowa University

1964 Ed.D., Education
Indiana University

Academic Positions at University of Minnesota, Duluth

1964 Assistant Professor of Education
1967 Associate Professor of Education
1970 Professor of Education

Administrative Positions

1969-1979 Chair, Department of Special Education
1980 -1984 Associate Dean,
College of Education and Human Service Professions
1988-1992 Chair, Department of Child and Family Development

Teaching Fields

1. Human development and educational psychology
2. Applied behavior analysis
3. Educational testing and measurement
4. Instructional methods for the learning disabled
5. Literacy skill acquisition

Research Areas

1. Interactions of evaluation anxiety and cognitive rigidity on literacy skill acquisition.
2. Interactive learning disk technology development.

Kent Peterson

Benson, MN 56215 ● 320-321-4848 ● petersonrestoration@gmail.com ● **WWW**: Bold Profile

Professional Summary

Dynamic market gardener and bee keeper with a proven track record at self-employment, excelling in optimizing crop yields and enhancing soil health. Skilled in farm equipment operation and customer relations, I implement innovative techniques for sustainable practices, ensuring high-quality produce and excellent service at farmers markets. Committed to continuous improvement and education in the field.

Skills

- Farm equipment operation
- Food safety regulation
- Customer relations
- Mechanically inclined and trained

Work History

Market Gardener/bee Keeper, 01/2019 to Current
Self Employed – Benson, MN

- Managed greenhouse operations for seed propagation, transplant production, and climate-controlled growing environments resulting in earlier harvests.
- Stayed informed of industry trends, research findings, and best practices through participation in conferences, workshops, and networking events to continuously improve market gardening operations.
- Optimized plant growth with careful pruning, thinning, and trellising strategies tailored to specific crop needs.
- Achieved higher quality produce with proper soil management practices and optimal fertilization schedules.
- Increased crop yield by implementing effective planting and cultivation techniques.
- Improved soil health through the addition of organic matter, composting, and cover cropping techniques.
- Ensured timely delivery of fresh produce to clients by coordinating efficient transportation logistics with local distributors.
- Reduced pest issues through the implementation of organic pest control methods for healthier produce.
- Streamlined planting processes using innovative tools and equipment to reduce labor costs and

improve efficiency.

- Developed strong relationships with customers by providing excellent service at farmers markets and other retail outlets.
- Evaluated and sourced high-quality seeds, plants, and materials from reputable suppliers to ensure consistent crop quality and variety selection.
- Enhanced sustainability efforts by incorporating water-saving irrigation systems and rainwater collection methods.
- Transplanted seedlings and young plants to promote growth and prepare plants for sale or transfer to other locations.
- Inspected equipment and machinery to identify and schedule repair and maintenance, managing wear and tear.
- Inspected plants to identify for signs of disease or infestation and address problems early.
- Educated employees and members of public on plant biology and health.

Education

High School Diploma: 06/1977
Benson High School - Benson, MN